Maize: New Uses for an Old Crop

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Image source: www.goodyear.com

Links to this presentation can be found under “Presentations & Papers”
Maize is an old crop!

- Genetic modification of maize has been occurring for thousands of years.
  - Center of origin = Mexico, central America
  - Earliest plant breeders = women
  - Important source of human and animal sustenance
- The miracle of maize is manifested in the thousands of ways that the grain has been used for years.

Many uses of maize...

- Alcoholic beverages
- Animal feed
- Baking, snack foods
- Other beverages
- Building materials
- Canners/packers
- Cereals
- Chemicals
- Condiments
- Confectionary
- Fats & oils
- Formulated dairy products
- Fuel alcohol

Source: Corn Refiners Association
Many uses of maize ...

- Household needs
- Ice cream/frozen desserts
- Jams, jellies, preserves
- Meat products
- Mining/metallurgy
- Misc. foods
- Misc. industrial
- Prepared mixes
- Paper & related products
- Paste, adhesives
- Syrups, sweeteners
- Textile
- Tobacco

Source: Corn Refiners Association
U.S. maize use...

Million bushels

- **Food, alcohol, industrial**: 2025
- **Seed**: 20
- **Feed & Residual**: 5825
- **Exports**: 1925

U.S. food & industrial use...

Specialty grain traits...

- Characteristics that add value to end-user...
  - Blue
  - Hard Endosperm/Food Grade
  - High Amylose
  - High Lysine/Opaque
  - High Oil
  - High Oil/High Oleic
  - High Starch
  - Low Phytate

- Extraordinary traits...
  - Low Stress Cracks
  - Low-Temperature Dried
  - Non-GMO Corn
  - Nutritionally Dense
  - Nutritionally Enhanced (sometimes called High Protein)
  - Organic
  - Post-Harvest Pesticide Free
  - Waxy
  - White

http://www.vegrains.org
New uses in their infancy...

- **Tires (BioTred™)**
  - “…micro-droplets of corn starch as a tire ingredient to reduce tire weight and rolling resistance.”
  - “…less energy to produce and their lower rolling resistance is expected to reduce fuel consumption and noise.”

[Image source: www.goodyear.com]

http://www.iowacorn.org/newuses.htm
http://www.goodyear.com/media/pr/22251ti.html
New uses in their infancy ...

- HarvestForm™, a polymer composite manufactured from maize and soybean polymers.
  - Deere® claims that all combines manufactured in 2002 would include panels made from this new composite.

New uses in their infancy...

- Compostable plastics...
  - Compostable plastics, packaging films, fast food serving utensils manufactured with maize-based polylactic acid (PLA).
  - “…takes less fuel to produce and breaks down into natural components – water and carbon dioxide – when composted.”

http://www.iowacorn.org/newuses.htm
New uses in their infancy ...

- Plastic foam...
  - Loosefill packaging material also manufactured from maize PLA.
  - Non-static (great for electronics)

http://agproducts.unl.edu/plastic.htm
New uses in their infancy ...

- Clothing, carpeting, textiles, bedding...
  - “Corn-based PLA can be blended with cotton, wool and silk to make exercise clothing, suits, even a 100% corn-fiber wedding dress.”

NatureWorks™ at http://cargilldow.com

http://agproducts.unl.edu/plastic.htm

Cargill Dow partnership...

- NatureWorks™ production facility in eastern Nebraska.
  - Targeted production of 140,000 metric tons of PLA per year.
  - Targeted maize usage of 1,000 metric ton of maize processed per day.

NatureWorks™ at http://cargilldow.com
New uses in their infancy ...

- Antifreeze from maize...
  - “Levulinic acid.....has proven to be an effective ingredient in antifreeze. This chemical could replace the toxic, petroleum-based ingredients now in use.”

http://agproducts.unl.edu/antifrez.htm
New uses on the horizon...

- Plant-based manufacture of pharmaceuticals & therapeutics
- Crops as an oral delivery system for vaccines and other health-related products

Examples:
- Prodigene
- Epicyte
- Monsanto
- Meristem Therapeutic
Epicyte

- Plant-based manufacture of human monoclonal antibodies (Plantibody™)
  - Partners w/ Dow Chemical & Dow AgroScience
  - Rice and maize = targeted crops
  - Oral, topical, inhaled modes of delivery
    - Herpes simplex virus (clinical trials 2002)
    - Respiratory Syncytial Virus
    - Clostridium difficile-associated diarrhea

http://www.epicyte.com
Prodigene...

- Maize-based manufacture of...
  - Oral vaccines
    - Hepatitis B
    - Lt-B (*E. coli* toxin assoc. w/ traveler’s diarrhea)
    - Transmissible gastroenteritis virus (swine)
  - Therapeutics (e.g., aprotinin)
    - A human therapeutic protein that is commonly used to control blood loss during surgery.
  - Industrial enzymes (e.g., laccase, trypsin)
    - Proteins used in applications such as laundry detergents, paper bleaching and food processing.

Long term goal:
Oral delivery system for an AIDS vaccine
Monsanto Protein Technologies

Maize-based manufacture of therapeutic proteins.

“Monsanto’s experience and technology in corn (maize) has enabled the development of a manufacturing process compatible with the stringency of pharmaceutical and regulatory standards.”

“Additionally, pharmaceutical proteins are stable in corn (maize) and can be expressed in large quantities of protein, while potentially lowering the costs of goods.”

http://www.mpt.monsanto.com
Meristem Therapeutics...

- Plant-based manufacture of therapeutic recombinant proteins.
  - Mammalian gastric lipase (maize) for treatment of exocrine pancreatic insufficiency common to cystic fibrosis and pancreatitis patients.
    - Clinical trials at the moment.
  - Human lactoferrin (maize), a natural defense protein against infections.
  - Collagen (tobacco), for skin and tissue repairs.
  - Human serum-albumin (tobacco), to expand blood volume in critical situations (surgery).

http://www.meristem-therapeutics.com
New uses via transgenics...

- The use of transgenic technology to develop crops with desirable, but heretofore unachievable, output trait characteristics is accompanied by several challenges.
  - Public acceptance of transgenics to date.
  - Uncertainty about the agronomic acceptability of the resulting varieties.
  - Increased need for I-P segregation at both the farm and grain handler levels.
Public acceptance...

- Most, if not all, of the transgenic agronomic crops commercialized to date have no clear benefit to the consumer.
  - Insect resistant and herbicide tolerant crops benefit primarily the producer.
  - Indirect benefits to the environment.
- The next generation of human health transgenics may lessen public concern.
Agronomic adaptability...

- Can be an issue with any specialty grain if the genetic background is “old” or simply deficient in agronomically important traits.
  
  - May not be an issue if value of grain is great enough to compensate for lower yield per acre.
  
  - May not be an issue if grain production is simply a component of a larger vertically integrated manufacturing system (from seed to pill) owned by a single biotechnology firm.
Containment & I-P needs...

- Containment of maize pollen is challenging to say the least.
  - Production in isolation among best options.
  - Genetic pollen incompatibility may be an option.

- Segregation of grain after harvest is achievable, but requires...
  - Additional expense (labor & equipment)
  - Diligence to detail

May not be an issue with vertically integrated systems
Philosophicating on new uses

- Profits associated with new uses will accrue to those who play the “game”.
  - The seed developer
  - The producer
  - The grain buyer
  - The manufacturer
  - The wholesaler or retailer

- Unfortunately, the profits are not often distributed equally to all of the players.
The challenge for producers...

- Figuring out how to participate meaningfully in the profit stream generated from the introduction of a new product or process that uses an enhanced maize trait as an input.

- Producers can...
  - Produce & sell the enhanced maize trait for a significant premium, and/or
  - Participate as an investor or partner in the new venture itself.
Producing for a premium...

- The track record to date for significant price premiums paid to producers for specialty grain production is not particularly encouraging.
  - Buyers and/or end users will always pay the least they possibly can for raw input.
    - Especially if the grain production is part of an overall larger vertically integrated system.
Typical niche markets...

- By definition, fill up quickly.
  - When the demand for the raw input is reasonably low, requiring reasonably few acres to produce, the market can become saturated quickly.
  - Requires producers to wisely identify opportunity early, be the first to participate in contract production, and know when to move to new opportunity before market drops.
  - High oil corn, white corn, waxy starch corn in the U.S.
Participate in profit stream...

- Opportunities exist for producers to cooperatively form new ventures.
  - Corn masa production facility in SW Indiana
    - Targeted at tortilla mfgr thousands of miles away in Georgia.
  - Ethanol production facility in NW Indiana
    - Proximity of nearby “mega” dairies offer sales outlet for distillers’ grain by-product high protein or energy grain feed.

A final disclaimer…

“An expert is one who knows more and more about less and less until he knows absolutely everything about nothing.”

-- Nicholas Murray Butler